(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

06 APR 2005

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 May 2004 (06.05.2004)

PCT

(10) International Publication Number
WO 2004/038891 A2

(51) International Patent Classification[7]: H02J 13/00

(21) International Application Number: PCT/NO2003/000334

(22) International Filing Date: 7 October 2003 (07.10.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20024833 7 October 2002 (07.10.2002) NO

(71) Applicant (*for all designated States except US*): **PRO-TURA AS** [NO/NO]; Olav Brunborgs vei 4, N-1369 Billingstad (NO).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **HANSEN, Roger** [NO/NO]; Olav Brunborgs vei 4, N-1369 Billingstad (NO).

(74) Agent: **BRYN AARFLOT AS**; P.O. Box 449, Sentrum, N-0104 Oslo (NO).

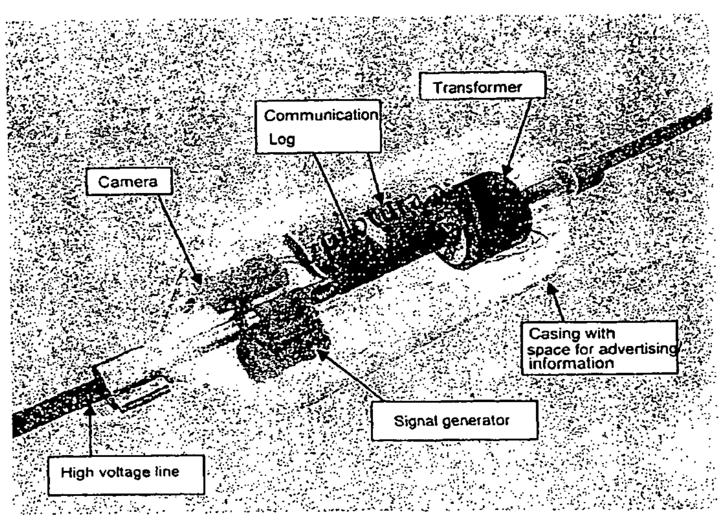
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** MONITORING SYSTEM AND DEVICE FOR AN ELECTRIC POWER LINE NETWORK



(57) **Abstract:** A device is provided for monitoring an electric overhead line, which device is constituted by an independently operating real time multisensor for mounting in a position on a span of the overhead line. The device has a built-in transmitter for transmitting sensor signals to a remote central, and comprises a laser range finder for measuring distance to the ground beneath the overhead line, as well as a camera for visual inspection of the line and its surroundings. Further, there is provided a system for maintaining the operation of a power line network, based on remote-controlled shut-off of switches installed in special appliances, particularly electric hot water tanks, at the premises of small consumers/private households.

WO 2004/038891 A2

ATTACHMENT A

BEST AVAILABLE COPY

10/530355
JC13 Rec'd PCT/PTO 06 APR 2005
WO 2004/038891 PCT/NO2003/000334

Monitoring system and device for an electric power line network

The present invention relates to a device for monitoring an electric overhead transmission line, and a system for maintaining operation of an electric power grid.

Power lines for transmission of electric power are dimensioned for the amperage to be transmitted, and for the length of the line spans in question. In addition, due consideration must be taken with regard to exposing the line span to wind, as well as the weighing down by snow and ice in northern areas.

It is a general physical fact that electric current flowing through a line will heat the line, and the degree of heating is connected with the amperage. Overheating leads to an expansion of the metal in the power line, and as a consequence of this, the power line will experience a sag increase, which means that the distance to ground level is decreased, possibly past a predetermined safety distance/minimum distance. In certain cases, strong heating for instance due to a large amperage, may give a situation where it is unsafe to stay underneath the power line.

In the warm season, and particularly in warm world regions, the power lines may become strongly heated by the sun and by a generally high air temperature, and if currents are then transmitted with amperages approaching the maximum amperage for which the line is designed, the wire may experience such a large sag increase that it will be perilous to enter the area thereunder. Also in other areas the increase of sag for the power lines in summer, may cause that the distance to trees thereunder will be too short. This may cause a flashover from the power line to the trees, and may result in forest fires and electrical power failure.

In other words, the power network companies may experience the problem that it is difficult to transmit the energy amount that the power line was actually constructed for.

In areas where power is delivered from nuclear power plants and thermal power plants, which plants have a laborious and slow manner of regulating the power production, the consequence is that it is difficult to transmit a high amount of energy just when the need is at the greatest. This leads again to the consequence that power suppliers and energy companies lose large amounts of money every year.

The power suppliers have no commercially accessible solutions for surveillance of the line network with regard to avoiding the above mentioned problems. Hence, a power supplier may be under the delusion that the energy transmission takes place in accordance with statutory safety routines and with the necessary safety margins, but has in reality no control over ambient temperature, solar heating etc. that in reality will determine the transmission capacity of the line.

The problem can be solved by building more power lines and stronger power lines, which may give a possibility to increase the safety margins, but this is a rather lengthy and costly process, and in addition, it is difficult to get a concession for new line profiles. Therefore, this solution is not of interest in most cases.

One is aware that a system has been developed for determining the temperature in a power line through measuring air temperature, and considering possible cooling effect of wind or rain. Thereby it is supposedly possible to calculate the amount of energy that can be transmitted at any time without any danger of overload. This calculating method has been taken in use in many countries, and provides a tool for the power plants for determining transmission capacity hour by hour. The method is based on weather forecasting and mathematical treatment of expected meteorological data in areas where the power lines are situated. As everybody knows, meteorological data are more or less reliable. The method has, naturally, turned out not to be sufficiently reliable with regard to the needs of the power companies.

From US Patent No. 5,341,088 is previously known a multisensor device that is mounted in a position on a power line span in order to perform real time monitoring of line temperature, air temperature, line current, solar irradiation, wind speed, wind direction and line slope at the multisensor position. From the slope, the multisensor calculates the line span sag, i.e. how low the lowest point of the line span lies below the suspension points. Measurement data regarding calculated sag and other parameters are transmitted via radio to an operation central that may make decisions regarding continued operation, on the basis of the measurement data.

However, the prior art as represented by the above mentioned US Patent, is not always capable of providing a correct picture of the situation. If for instance snow and ice load occurs on a line span, the calculation from slope to sag will be erroneous, and besides, a snow layer of for instance 2 m on the ground underneath the line, or possibly vegetation growing rapidly, will result in quite different actual distances

between line and terrain, than what the prior art will calculate from the measurements.

Besides, this prior art does not outline any radical solution methodology for the acute problem that a network company may experience, namely when a shut-off must be made for some hours in order to save a network from damage in an established critical situation. Energy-intensive industry companies that lose power, often have an agreement regarding compensation for such cut-offs, and this may result in large economical losses for a network company.

The present invention aims at solving the above mentioned problems, and the solution in accordance with the invention appears in two main aspects:

Firstly, the present invention presents a system for maintaining the operation of an electric power line network, and the system is defined precisely in the appended claim 1, and favourable and preferable embodiments appear from the attached claims 2-9.

Further, the present invention presents, still in accordance with the first aspect, a multisensor device to be mounted on a span of a power line, the multisensor device being defined precisely in the appended claim 10, and favourable and preferable embodiments appearing from the attached claims 11-13.

In the second aspect of the invention, there is presented a device for monitoring an electric overhead line, and the device is defined precisely in the appended claim 14, and favourable and preferable embodiments appear from the attached claims 15-24.

In short terms, it can be expressed that the combination of a laser range finder directed downwards and camera surveillance, will provide exact distance to the ground as well as a visual confirmation of the situation. Further, it is an important novelty to be able to detect and provide a warning regarding power line galloping, by means of measurements with "inversely" mounted mercury switches for detecting "inverted sag" (verified by laser range finder and camera). Sideways galloping due to strong wind can also be detected in a similar manner.

Hence, the present invention provides the possibility of real time regulating of maximum transferable power, since it will be possible to monitor continuously from a power plant the condition of the power lines in question, so that overload, forest fire

and dangerous passage of persons can be avoided, while at the same time capacity of the lines can be utilized at a maximum.

In the following, the invention shall be described more closely by going through some detailed embodiments, and with reference to the appended drawings, where

Fig. 1 shows an embodiment of a device in accordance with the invention, mounted on an overhead line, and with an outer casing that is transparent for illustration purposes,

Fig. 2 shows an alternative embodiment of the device in accordance with the invention, having a "split" construction,

Fig. 3 shows an example of an image from a camera included in the device in accordance with the invention,

Fig. 4 is a sketch showing multisensor devices deployed in a large power line network with power plant, operation centrals and branches to typical town areas/densely populated areas and to energy-intensive heavy industry,

Fig. 5 shows a diagrammatical system sketch over the influence of the multisensor devices on appliances in the premises of individual end consumers (small consumers),

Fig. 6 shows a corresponding system sketch as in Fig. 5, however with emphasis on alternative signal paths,

Fig. 7 shows one optional monitoring image on a computer display unit in an operation central, and

Fig. 8 shows another optional monitoring image.

As mentioned above, one of the aspects of the invention consists in a device that can be designated as a "multisensor" that is able to detect, and output signals regarding, a plurality of parameters that are of importance for power lines. In a particular case, it is not necessarily important to monitor all parameters, but some of the parameters mentioned here, will always be of interest: it concerns line temperature, which is measured by a probe that engages the line itself, air temperature to be measured by a probe directed outward into the air, line slope or line sag increase, galloping, wind speed, wind direction, concentration of precipitation particles in the air, distance to ground level, quality of line current, snow/ice load on the line, and a visual image of the line.

Increase of line sag ("sagging") is measured by detecting a slope angle, for instance by means of mercury switches. Sag increase can be due to various factors, such as previously mentioned. If the sag increase measurement is set in connection with a temperature measurement, snow and ice load can be determined. The quality and stability of current flowing in the line can be measured by means of a measurement

transformer, while wind speed and wind direction are measured by means of a traditional wind gauge. The distance to ground level is measured separately by means of a built-in laser range finder. The concentration of raindrops or snow particles in the air can be measured by a laser particle counter that comprises a mirror for a light fan from a laser. Rain and snow have a cooling effect on a line, and such a cooling influence is a factor that must be included in a prognosis.

In addition, the multisensor includes "visual safety backup" by having mounted therein a camera that can be used to see visually the various warning signals. Besides, the camera has an independent function for monitoring the line itself, weather conditions around the line and vegetation below the line.

Warning regarding "galloping line" has been mentioned above, and this means a warning regarding a damaging phenomenon for a line, namely a vibration mode in which a waveform propagates along the line, usually started by wind. A propagating wave, or for that matter a standing wave, along the line may have amplitudes large enough to result in damage. It is therefore important to detect such a motion, i.e. receiving an automatic warning regarding such a motion from a sensor device in accordance with the invention, because then the current can be shut down before destruction occurs, and the damage can then be limited.

As regards automatic warning signals, so-called "critical" sag can be mentioned, which means that the sag increases beyond a previously set criterion. When this situation is signalled as an automatic warning from the sensor device in accordance with the invention, the amperage can be reduced if the increased sag is due to heat in the line. Or some action can be started to remove possible snow/ice load from the line span if weighing down should be the cause of the exaggerated sagging.

It is referred to fig. 1, where a preferable embodiment of a device in accordance with the invention appears, mounted on an overhead line. For illustrative purposes, the outer casing is transparent.

The device is attached tightly to the high voltage line and surrounding the line. Inside a weather-proof outer casing, made for instance of a strong plastic material, there are instruments of the above mentioned types: a camera is arranged so as to peer out through a window with a field of view along the line and preferably below the line. A transformer is arranged to collect operating power from the very current through the line, and in connection with this power transformer there is also a measurement transformer for checking the stability and quality of the line current. In a separate box, sensors/signal generators are arranged for sag measurement, in the form of mercury switches. In the same generator box there is also circuitry for generating signals

regarding temperature in the line and the surrounding air, respectively, and these signals are generated on the basis of measurement signals from temperature probes engaging the line itself, and outside the outer casing.

In the shown embodiment, the multisensor device also contains a log for recording measurements, as well as a communication unit, which unit is, in the preferred embodiment, able to perform two-way communication. This means that the unit, in addition to transmitting radio frequency signals to a remote central, is also capable of receiving control signals from the same central.

The preferred embodiment also comprises a wind gauge, which is not visible in the drawing. The wind gauge operates of course in connection with an opening in the outer casing. A laser range finder is incorporated in the signal generator box, and measures the distance to the terrain below, through a window in the outer casing.

For the rest, the outer casing comprises, in the preferred embodiment of the device, space for outside information or advertisement.

In fig. 2 appears an alternative embodiment of the device in accordance with the invention. In this embodiment it appears that a central section that contains a current transformer for fetching operating power from the magnetic field of the power line, is divided in two so as to make the installation on the power line simple and rapid. The two box-like units on the sides contain single sensors of the above mentioned types, there is for instance an opening shown in the front left side for an internal camera, and in addition there is communication equipment and a possible logging means.

In fig. 3 appears an image recorded by a camera built into a device in accordance with the invention, which image shows the situation around the line such as it would appear visually, and in addition a bar has been laid in at the top of the picture, to show the temperatures of the air and of the line. Such an image can be transmitted as a radio signal.

As previously mentioned, the device in accordance with the invention constitutes a multisensor, which means that the device is able to measure a number of different parameters, but the device can also be specially adapted to deal with fewer parameters, or possibly more parameters, depending on the conditions in the actual location. What is regarded as minimum equipment in the sensor, are a slope gauge and temperature probes for air and line temperatures, laser range finder and camera. The slope gauge, preferably in the form of a mercury switch or relay with a ball (ball relay), provides information regarding sag, namely when the slope angle changes and becomes steeper, and the temperature probes provide information regarding the reason for the possible sag increase, namely either overheating of the line, or ice/snow load at low temperatures. The temperature probes are preferably bimetallic

temperature probes. Correct distance to structures below the line, is measured directly by a laser range finder, and the measurement is double-checked by the camera surveillance.

The remaining sensor types that have been mentioned, are optional. Transmission equipment is obligatory, but receiver equipment for receiving control signals, should preferably be included also.

A simple and effective design of the multisensor can work in the following exemplary manner: bimetallic temperature probes are connected in series with slope angle gauges, for instance in the form of mercury switches. The mercury switches operate by forming contact, or breaking contact, depending on the inclination of the switch. Thus, the mercury switches are mounted in the multisensor with adjustment screws so that a default angle can be adjusted, and then in such a manner that contact is formed or broken for a certain angle of inclination. In other words, with this type of slope gauge it is detected only whether the angle of inclination is above or below a certain limit angle. However, several such gauges can be mounted if it is desirable to have detection ranges of finer graduation.

Since the multisensor in accordance with the invention shall always measure the slope of the line, the sensor must be mounted at a proper distance from the mid-point of a span, because at mid-point the slope will normally be equal to 0, no matter how much the sag is increased. This means that the sensor can advantageously be mounted in an area midway between a pylon and the mid-point of the span, or possibly even closer to the pylon.

One or several mercury switches/slope gauges for detecting change in sag, were mentioned above. In a practical case, the preferable number could be two such gauges, namely one regarding "50%" of a critical value, and one further mercury switch for the critical value itself.

In order to distinguish between cases of increased sag for the line caused by snow loads and caused by high line temperature, functions have been built in to set threshold values for line temperature in beforehand. If the line sags to a detection value, and the line temperature is for instance lower than a certain pre-set temperature threshold value, the sensor will provide a signal indicating snow/ice load. On the other side, the sensor will be able to provide a signal regarding increased sag due to exaggerated heat in the line, if a line temperature is detected that is higher than a pre-set threshold value. Hence, it is realized that the sensor in such a case transmits a signal of interest based on two conditions detected at the same time.

With the camera mounted in the sensor device, it will possible to verify the signal in question, via the camera.

Also a signal regarding a galloping line is obtained on the basis of the same technical solution, using for example a mercury switch as a slope gauge, but then a mercury switch which is turned 180° relative to the above mentioned mercury switches. Thus, the galloping detector responds to an inverse slope of the line, which is typical for the galloping phenomenon. Since this phenomenon is of a rapid and transient type, measures are preferably made to avoid that a galloping signal arises and disappears in step with the galloping. Therefore, a relay is mounted and set for a desired, timed hold contact, or the signal must be signed out. Hence, greater security is obtained regarding detecting an incoming galloping signal in the central.

Besides, galloping may occur in two perpendicular planes, namely mostly in the plane spanned by the line span itself, which is a vertical plane, but the oscillations may also occur in a horizontal plane. Experiments show that galloping in both planes can be detected by means of one and the same mercury switch.

The laser range finder checks continuously the distance from the line to the ground level, and consequently the remaining signals regarding line deviations, i.e. increased sag and possible galloping, can be verified.

To ensure that the previously mentioned sensors work properly, it is important that the multisensor does not twist around the line. The sensor should therefore be attached firmly from the start, but in addition, if the line itself is exposed to twisting movements about its axis, the sensor could be equipped with a cylindrically rotatable suspension to ensure that the multisensor stays at rest relative to a vertical plane, i.e. that it does not rotate relative to the surroundings.

It is a separate point regarding the multisensor, that different measuring methods used at the same time, in collection will provide a reliable result. In the embodiment where a current transformer is used to provide energy from the power line itself, there will be no particular limitations regarding the energy demand of the sensor. In another embodiment adapted for power lines that do not transmit high voltage power, it is possible to use the actual current from two phase leads running in parallel next to the sensor device, in such a manner that the very current in the lines is used for powering the sensor. In another embodiment, for example adapted to telecommunications lines, power current can be supplied separately via the nearest pylon carrying power current.

The sensor device preferably has transmitter modules for every signal to be transmitted. Preferably, it also contains a receiver system, so that it will be possible to activate the camera for visual inspection, or to activate other single sensors in order to double-check signals that have been received in the central. All signals are transmitted via the power company's own data system, which system is based on for instance the RTU system, possibly the Scada system, or using RF signals. All signals are logged. The central receives the signals and can make decisions regarding transmission of more or less power through the lines where the sensor devices are mounted. Because the sensor devices transmit signals to the central, where the signals are logged, it is possible to implement measures prior to a possible breakdown. As an example, it can be mentioned that if the control room receives a signal to the effect that a line span is galloping, this provides an opportunity to load power over to another power line before the first one breaks down, and in such a manner it will be possible to avoid power shut-off for some areas.

Further, the logging of the signals will provide a possibility for preparing trends and statistics for the various power lines where the system is mounted, so that it will be possible to have documented statistics based on real time measurements.

Since the system of the invention is based on real time measurements on the lines, the decisions that are made in the central on the basis of the sensor signals, will always be correct.

Regarding information/advertising on the outside of the multisensor outer casing, the pricing of the power company may appear there, or possibly the power amount that is transmitted through the line. Such an information device could of course be developed further to be able to display variable information, particularly in a context as previously mentioned, where operating power can be taken from the line itself. In such a case, operating a variable display is no problem. This may be of special interest for instance where power lines cross communication arteries like for instance roads or canals.

Figs. 4 and 5 illustrate the system aspect of the invention. A number of multisensor devices such as described above, are indicated by circles in fig. 4, in many different places in the power network, both in a superior network (for instance with national coverage) and in more local branch networks. An important problem that is solved by the present aspect of the invention, is the problem of maintaining the operation of the network even when it is realized that a critical situation is building up (detected by the measurements of the multisensor devices). Previously, the problem has been solvable in a rather negative manner, namely by shutting down power to large

consumers, typically meaning energy-intensive heavy industry. This has resulted in compensation payment, that is an economic loss to the network companies.

The present invention solves the problem in a completely different manner, namely by remote controlled shut-down of certain appliances in the premises of small consumers, i.e. typically in private households. This entails that special switches with remote-control are installed in the premises of all (or many) small consumers, for such special appliances as for instance electric hot water tanks (domestic water heaters).

It turns out to be a fact that it means nothing, or actually very little, if an electric hot water tank is shut down for a time period of say two hours. Very few private households will experience any change in comfort level, or for that matter in power costs, if an electric water tank is shut down for such a period one day in order to maintain operation of the large power line network.

Of course, a high number of such appliances are shut down at the same time, and thereby the network load is lowered to a substantial degree, with the effect that a critical situation can be saved without having to shut down the network itself, or having to disconnect large power consumers.

The cut-off by means of remote-controlled switches at the premises of small consumers, will appropriately be made for pre-determined time periods, for instance by having a built-in timer in every switch, which timer will provide re-connection after two hours, for instance. Or possibly, a re-connecting signal can be transmitted in the same manner as the transmission of the disconnect signal.

A shut-off signal can, in one embodiment, be transmitted from an operation central, after an automatic or operator-controlled decision about this in the central on the basis of data reported in, including possibly camera images, from topical multisensor devices on the power lines.

But it is also possible that such a multisensor device makes a decision quite autonomously, using built-in microprocessor intelligence, that it is quite necessary at this point of time to lower the amperage, and thereby the multisensor device itself transmits a signal, for instance a radio signal, to provide for a remote-controlled shut-down of appliances directly in the premises of the small consumers. This may require a powerful radio transmitter in the multisensor device for covering a given "catchment area", but it is also possible to establish relay stations for forwarding such a signal to other areas or larger areas, to ensure that the signal will be received by the topical remote-controlled switches in the households.

Fig. 5 illustrates an embodiment where data signals from a multisensor device (at the top) are conveyed to a collecting central and further on to local operation centrals, and there is here a possibility that a decision about block disconnection/sectioning can be made at several levels, having effect for larger or more local areas, that is for more or fewer small households (at the bottom of the drawing). It appears also from the drawing that a multisensor device (top level of the drawing) in such an embodiment can use at least measurement of conductor temperature and air temperature, and possibly on its own calculates what will most probably happen to the line, while a measurement regarding line current is either made by the sensor device, or is made separately somewhere else (shown at the right side of the drawing).

In fig. 6 appears a similar sketch as in fig. 5. But here, emphasis is put on showing the various paths for a signal to an end user with regard to disconnecting for instance an electric hot water tank. From a multisensor device attached to a line, a direct signal, preferably a radio signal, may be sent, such as shown to the far right in the drawing, which signal is an order regarding shut-off. This direct signal may possibly be repeated/amplified by suitably deployed relay stations, but the point is that the full decision regarding disconnection is made in the multisensor device itself.

In a next case, such as shown to the far left in the drawing, the signal from a multisensor device may be sent directly to a local operation central, and the signal then in question, is not necessarily a command signal, but will preferentially be a monitoring signal containing information regarding the various parameters that have been mentioned earlier. Then, a decision regarding possible shut-down can be made in the local operation central, and the disconnection signal will be sent to the end users.

Finally, the drawing shows also the option that the multisensor devices report in their measured parameters to a national central, in which central decisions can be made regarding shut down, and a command signal can then be forwarded via local operation centrals and finally to the local switches at the end user's premises.

Fig 7 shows a possible monitoring picture on a computer display unit in an operation central. In the top part of the image, the monitored power line is identified. It is realized that this power line extends from location Røykås to location Fåberg, and it is a 300 kV line. Multisensor devices in accordance with the invention have been arranged in three special positions, namely position "Sinnataggen" with identification ID02, position "Ambolten" (ID03) and position "Gluggen" (ID04), and it is noted that the three locations would normally have been selected with a spacing of about 10 km. (In the drawing, it looks as if the three locations are in adjacent line spans, but this is merely a chosen visual design for the display picture.)

In the lower part of the display picture, the respective multisensor devices have their own areas with indications regarding important parameters.

Thus, if measurement parameters are considered for location "Sinnataggen" at the far left, one finds a measured air temperature of 54°C, a measured conductor temperature of 92°C, a measured snow/ice load of 0 kg and a measured distance to the ground that is 14,2 m. The measured temperatures and the distance to ground shows clearly that heat expansion has resulted in increased sag ("Sag") so that the distance to the ground is too short, and there is an indication "Heat Critical" just below "Sag" in the right column. The air temperature indicates clearly that the line is in a very warm area (here maybe excessively warm), and it seems clear that a shut-down must be executed.

The other indications in the right column under "Sinnataggen", are that a vibrator means that may be attached to the overhead line together with the multisensor device, or near the multisensor device, is shut off. The next indication is that there is no "galloping" condition for the line, and at the bottom there is an indication that a light source for the multisensor device camera is off.

If one takes a look at the location "Ambolten" at the middle of the page, somewhat more normal conditions will be found, the distance to ground being acceptable, namely 16,1 m, there is no snow or ice load, the conductor temperature is acceptable at 47°C, and the temperature is 26°C. It is not necessary with light for the camera, nor is it necessary with any vibrator operation to remove snow or ice. However, there is an indication of a galloping line. This may be a problem in its own right, started by a strong wind. Possibly, a camera picture should be used, so that an operator may decide whether the galloping condition is dangerous.

In the display part regarding position "Gluggen" at the far right in the picture, it is realized that position "Gluggen" would necessarily be relatively far away from "Sinnataggen" at the far left. The conditions at position "Gluggen" are winter conditions, the air temperature being -18°C, a snow/ice load of 72 kg is detected, and this results in a sag increase that is critical, with a distance to ground of only 11,1 m. At this position, there is also a need of light for the camera that is used to confirm the condition, and one can also see that a vibrator has been switched on, in order to try to remove snow and ice from the line. There is also detection of a galloping movement.

The three cases appearing in fig. 7 will in a practical case hardly appear in the same picture, but merely state examples of what may possibly appear as indications in such an image.

It may be of interest to take a closer look at one of the indicated locations, and an operator may then click directly on the image indication of a multisensor device, for instance device "Sinnataggen" in fig. 7. Thereby, a new image appears, like the one shown in fig. 8. The layout in fig. 8 is such as to show the measured parameters directly in an "actual position", for instance the conductor temperature appears as a mark on the line, i.e. 92°C, the distance to ground appears between the line and the ground as DG (Distance to Ground) 14,2 m, and air temperature appears "in the air" as "Air 54°C". In fig 8 appears also a yellow (bright) mark next to the sensor device, which means active camera lights. In this special case, the light was supposed to be "off", but in fig. 8 the bright marking that really means "camera lights on", appears just to show the indication itself.

In the lower part of the computer display picture shown in fig. 8, appear control buttons that can be clicked, one for a snow/ice vibrator, which in this case is "off", and to the right a switch for camera lights, which in this case is "on". A clickable button ("main") is arranged in the display picture to provide a possibility to return to the main picture (i.e. the picture of fig. 7).

In other words, one of the main tasks for the multisensor devices is to measure in real time the topical parameters that influence the ability of the power lines to maintain the function, that is conductor temperature, air temperature, sag, camera image with a general view and more, as mentioned above. These parameters are then transmitted as radio signals to an operation central, and are then deciding parameters regarding the transmission capacity of the line. The measurements from the multisensor device will also form a basis for the "rating" hour by hour for the line, i.e. it is desirable to determine with the real time measurements the transmission capacity of the power line with 100% certainty, hour by hour. (The reason for the time aspect "hour by hour" is the thermal inertia of the line.)

If it appears that the sag of the line becomes critical, the multisensor device will provide immediately an alarm for an operation central, and it may possibly transmit a trigger signal directly to households for disconnecting for example an electric hot water tank (or a similar apparatus where such disconnection does not lead to a comfort problem that is noticeable). This will have as a result, that the power line does not become overloaded, and the private households will not notice such a shut-down (during for instance one or two hours) of a domestic electric water heater, because the heater tank will be re-connected again for instance automatically by means of a timer.

This invention will result in a win/win situation for power supplier/network operator and customers, since such a short shut-down is not noticeable in the comfort of private households.

CLAIMS

1. System for maintaining operation for an electric power line network supplying power to energy-intensive industry and a high number of private households, comprising multisensor devices mounted on a number of spans of the power lines of the network, for real time monitoring with measurement of physical parameters with influence on the ability of the power lines to maintain desired power transmission, characterized in that the system further comprises local, remote-controlled switches inserted in the power supply line to electric hot water tanks or similar current-consuming appliances in the private households, and that the multisensor devices are operative so that measuring results of at least one thereof can cause a shut-off signal to at least a substantial number of the local, remote-controlled switches.

2. The system of claim 1, characterized in that the multisensor devices have microprocessor intelligence and transmission equipment, and thereby are operative to transmit a shut-off signal directly or via relay stations to the local, remote-controlled switches after autonomous decision regarding a critical situation with regard to the measured physical parameters and load on the network.

3. The system of claim 2, characterized in that the transmission equipment is radio-based.

4. The system of claim 1, characterized in that it further comprises an operation and control central for receiving report signals from the multisensor devices, the multisensor devices having signal transmission equipment, and the central further being operative to output a possible shut-off signal on the basis of a present report situation.

5. The system of claim 4, characterized in that the central comprises microprocessor intelligence for decision, in accordance with programmed algorithms, regarding whether a critical parameter situation is present and whether a shut-off signal should be transmitted.

6. The system of claim 4,
characterized in that the central comprises operator control, so that a decision regarding a possible critical situation is subject to human control.

7. The system of claim 6,
characterized in that the multisensor devices comprise camera for real time image surveillance of a power line and its surroundings, whereby an operator may check visually the situation at a multisensor device of interest, prior to making a decision.

8. The system of claim 6,
characterized in that the multisensor devices comprise circuitry for trigging an alarm signal, in order to draw an operator's attention toward a critical situation.

9. The system of claim 1,
characterized in that every multisensor device is an independently operating device to be mounted in a position on a power line span, with a built-in transmitter for transmitting signals for reception in local, remote-controlled switches or in an operation and control central, on the basis of measurements made with built-in sensors for detecting at least one parameter in a parameter group that comprises angle of inclination, line sag increase, wind speed, wind direction, quality/stability of line current, line temperature, air temperature, distance to ground and visual image of the line and its surroundings.

10. A multisensor device for mounting on a power transmission line span in a power grid that supplies energy-intensive industry as well as a high number of private households, for real time surveillance with measurement of physical parameters with an influence on the ability of the power transmission line to maintain the desired power transmission,
characterized in that the multisensor device is operative to cause transmission of a shut-off signal to local, remote-controlled switches arranged in the power supply line to electric hot water tanks or similar current-consuming appliances in the private households.

11. The multisensor device of claim 10, characterized in that it is equipped with microprocessor intelligence and a radio transmitter for transmitting a shut-off signal directly or via relay stations to the local, remote-controlled switches, after an autonomous decision regarding a critical situation with regard to the measured physical parameters and a desired amperage in the power transmission line.

12. The multisensor device of claim 10, characterized in that it has transmission equipment for transmitting a report signal to an operation and control central where a further decision is made regarding a critical situation and transmission of shut-off signal to the local, remote-controlled switches.

13. The multisensor device of claim 10, characterized in that it is an independently operating device to be mounted in a position in a power transmission line span, with a built-in transmitter for transmitting signals to an operation and control central or to local, remote-controlled switches, on the basis of measurements with built-in sensors for measuring at least one parameter in a parameter group that comprises angle of inclination, line sag increase, wind speed, wind direction, quality/stability of line current, line temperature, air temperature, distance to ground and a visual image of the line and its surroundings.

14. A device for monitoring an electric overhead line, the device being an independently operating real time multisensor for mounting in a position on a line span, with a built-in transmitter for transmitting sensor signals to a remote central, from built-in sensors for sensing at least one parameter in a parameter group that comprises angle of inclination, line sag increase, wind speed, wind direction, quality/stability of line current, line temperature and air temperature, characterized in that the multisensor further comprises a camera for real time image monitoring of the line and its surroundings, the camera further being operative to present at least one of said parameters visually as a part of the camera image, the camera image being transmitted as a sensor signal in real time to the central.

15. The device of claim 14,
characterized in that the multisensor further comprises a laser range finder for direct measurement of distance to ground right therebelow, said distance being included in said parameter group, and being presentable in the camera imag that is transmitted.

16. The device of claim 14,
characterized in that the multisensor further comprises bimetallic temperature probes, mercury inclination switches, ball relays, camera, wind gauge laser range finder and a measuring transformer, for sensing said parameters and f optional display in the camera image that is transmitted.

17. The device of claim 14,
characterized in that the multisensor is equipped with circuitry for providing a trigger function for transmitting an alarm signal when pre-set threshold values of temperature or others among said parameters are exceeded.

18. The device of claim 14,
characterized in that the multisensor comprises a current transforme for fetching operating power from the overhead line itself.

19. The device of claim 14,
characterized in that the multisensor comprises a system of solar cel and battery for providing operating power.

20. The device of claim 14,
characterized in that the multisensor or a part thereof is shaped as tv semi-cylinders hinged to each other, for mounting by folding the semi-cylinders together round the line.

21. The device of claim 14,
characterized in that the outer surface thereof is equipped with visibl information/advertising.

22. The device of claim 14,
characterized in that the multisensor comprises a receiver for control signals from the central.

23. The device of claim 14,
c h a r a c t e r i z e d i n t h a t the transmitter is a radio transmitter.

24. The device of claim 14,
c h a r a c t e r i z e d i n t h a t the transmitter is connected to the power line itself, in order to use the power line as a transmission medium to the central.

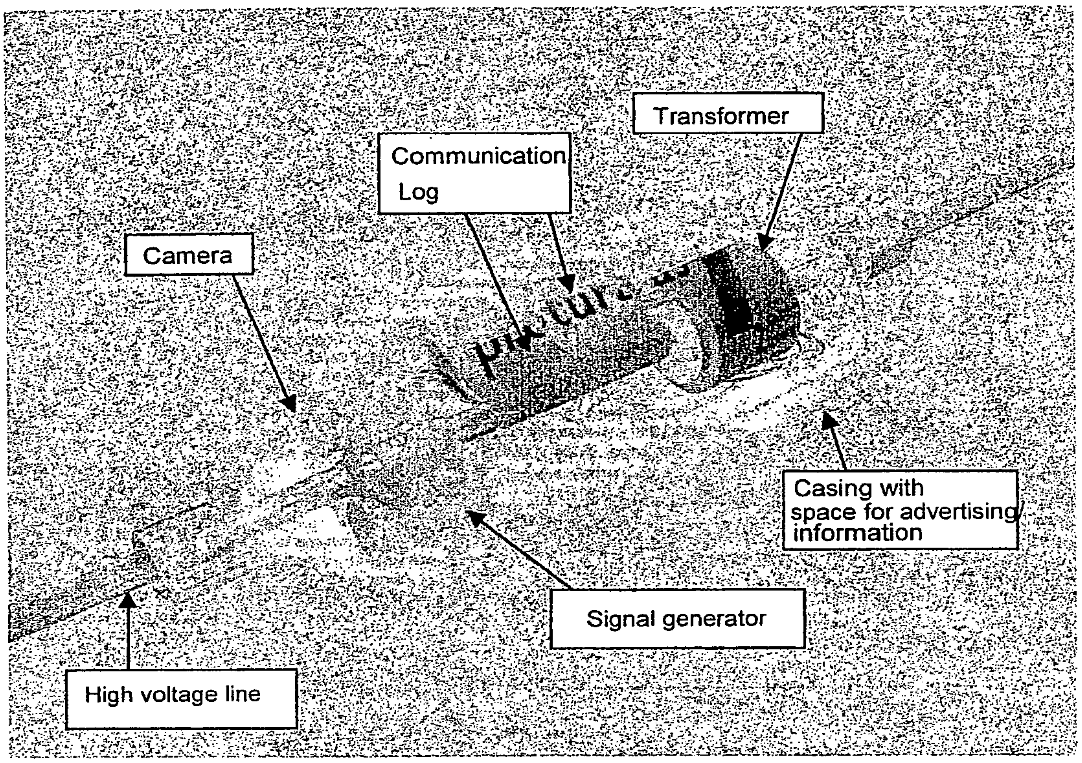

Transformer
Communication
Log
Camera
Casing with
space for advertising/
information
Signal generator
High voltage line

Fig. 1

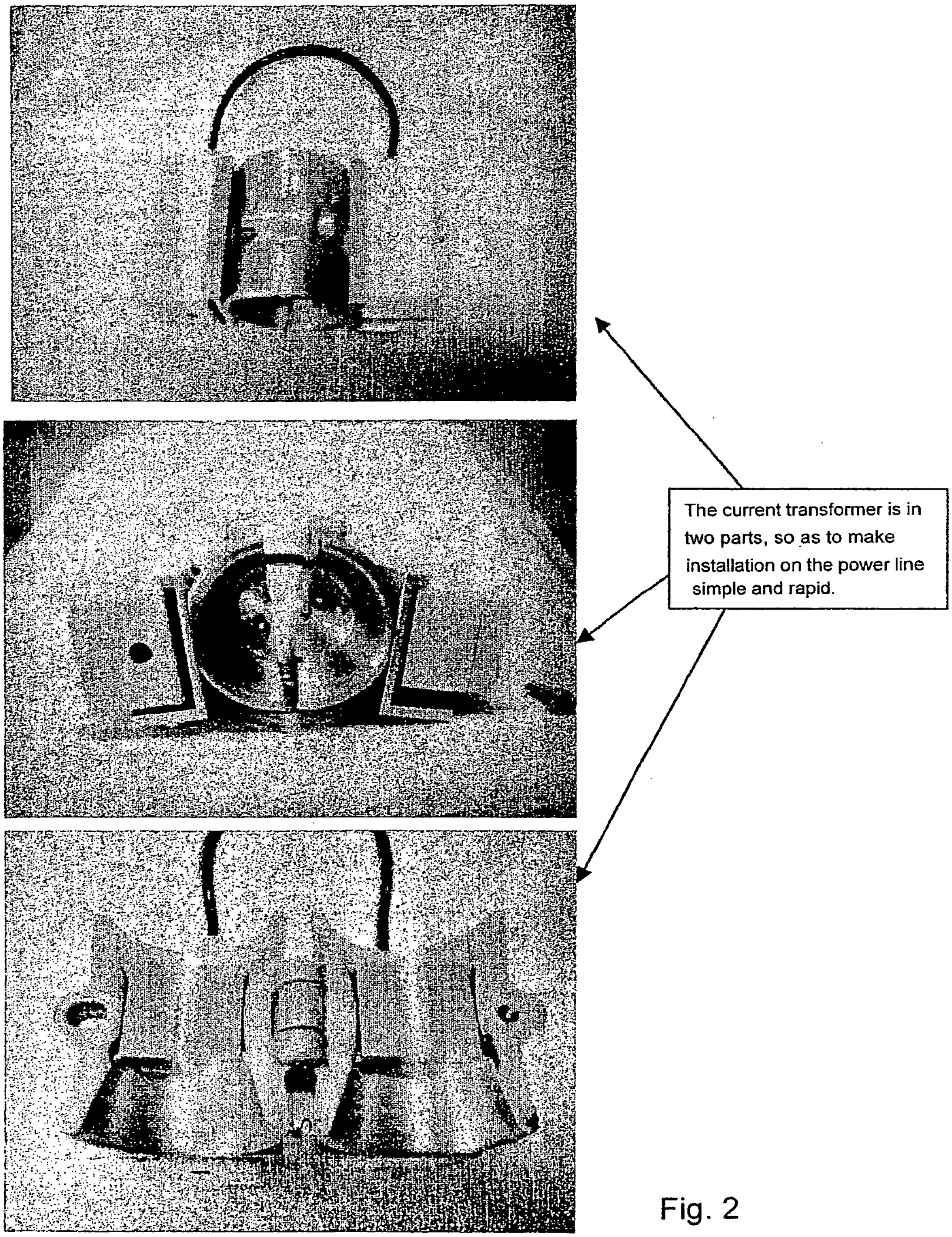

The current transformer is in two parts, so as to make installation on the power line simple and rapid.

Fig. 2

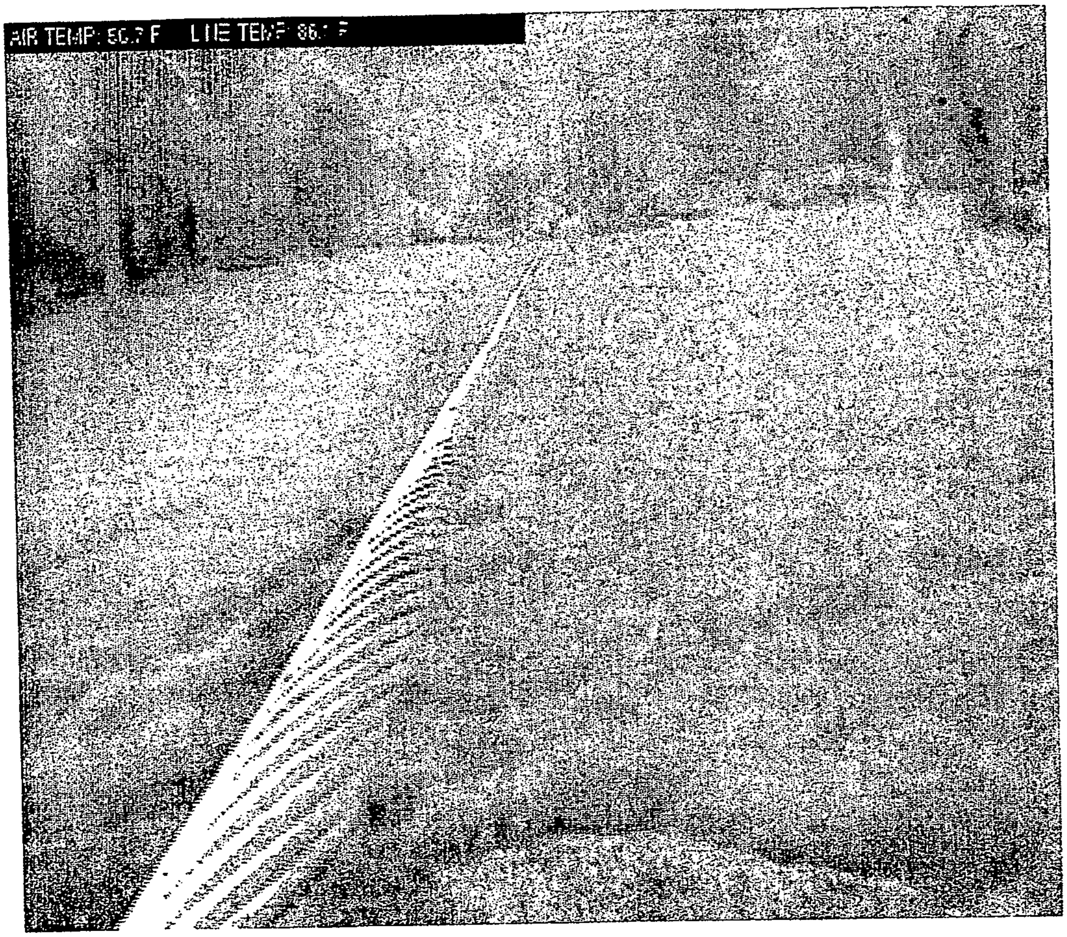


Fig. 3

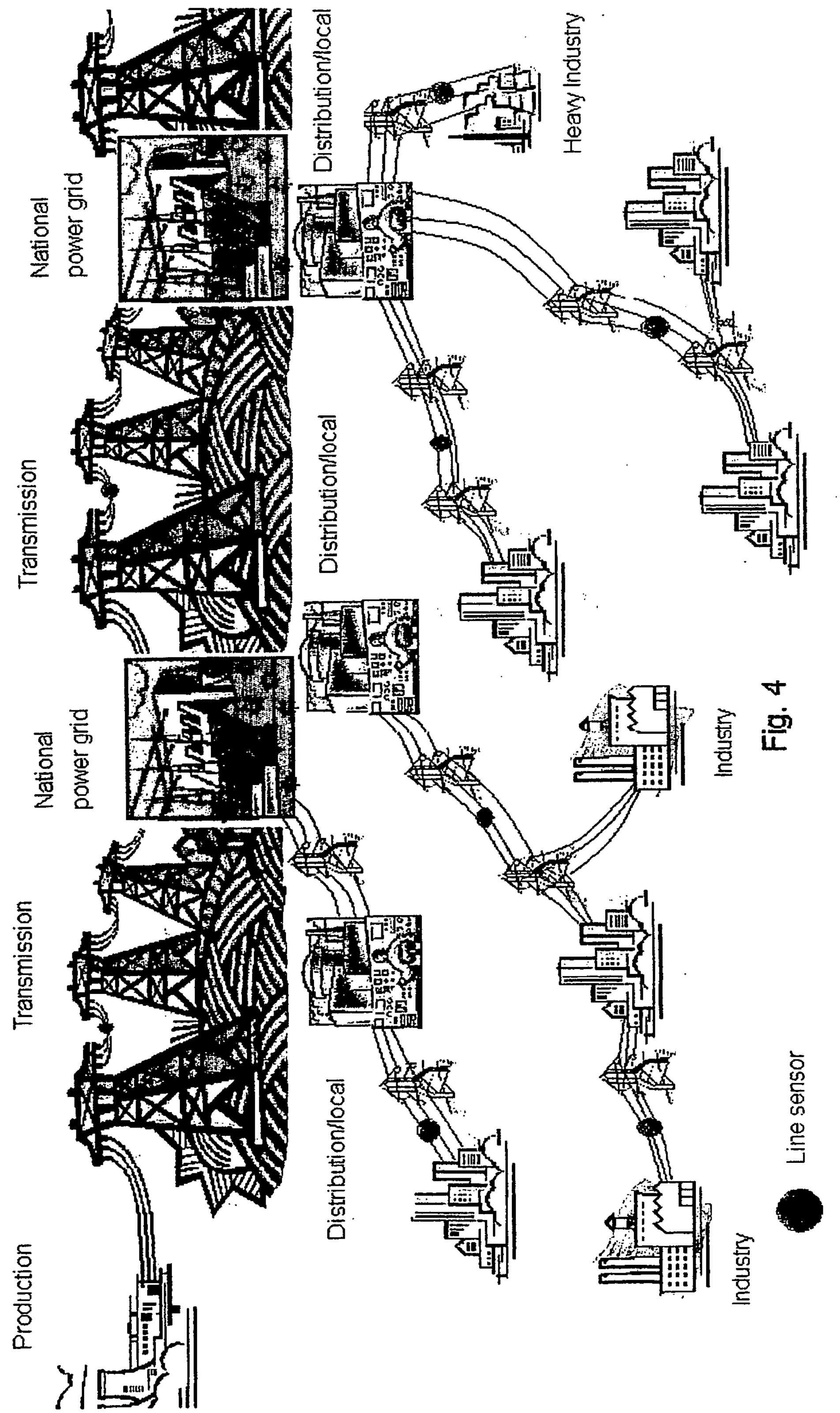

Production
Transmission
National power grid
Transmission
National power grid
Distribution/local
Distribution/local
Distribution/local
Heavy Industry
Industry
Industry
Line sensor

Fig. 4

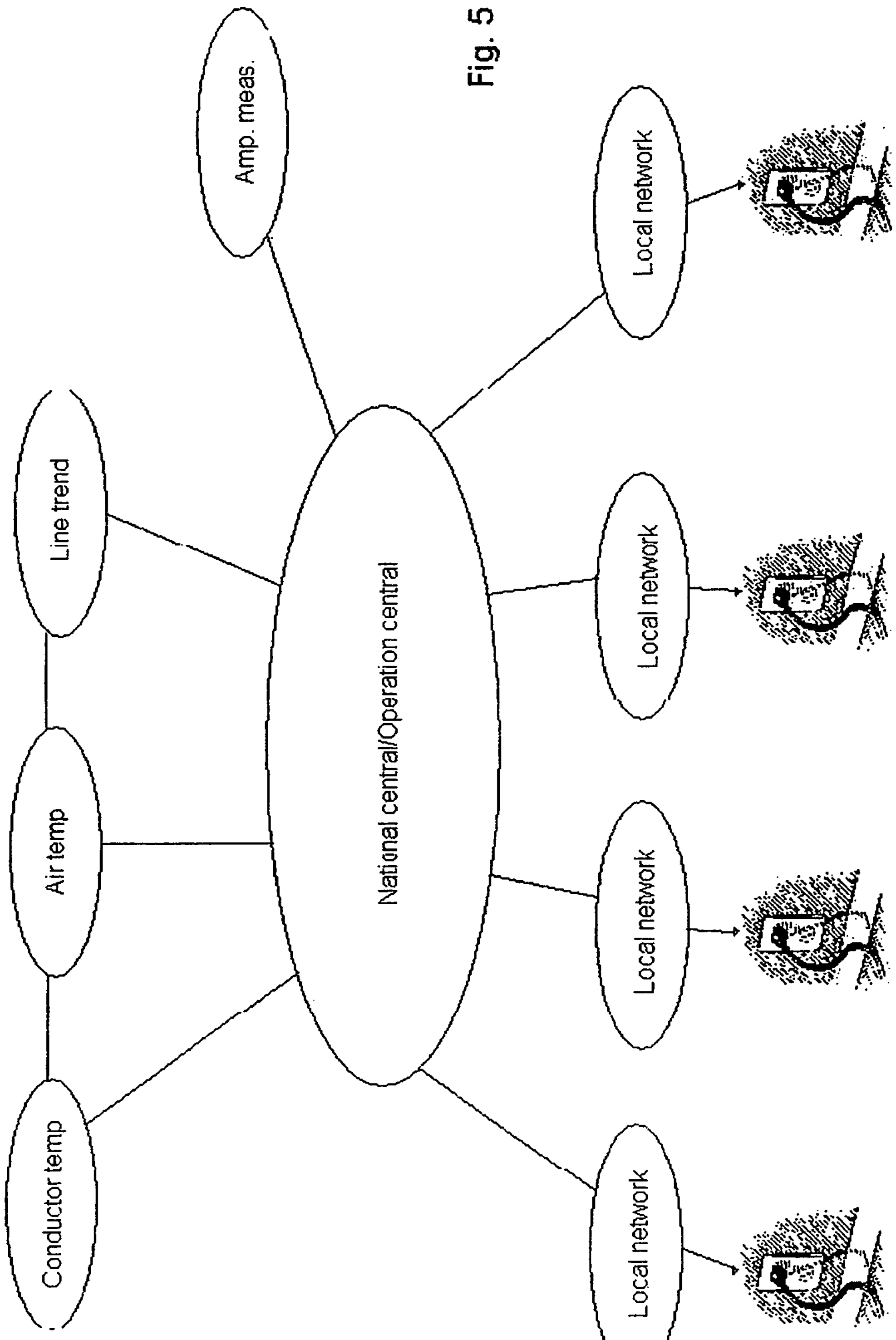

Amp. meas.
Line trend
Air temp
Conductor temp
National central/Operation central
Local network
Local network
Local network
Local network

Fig. 5

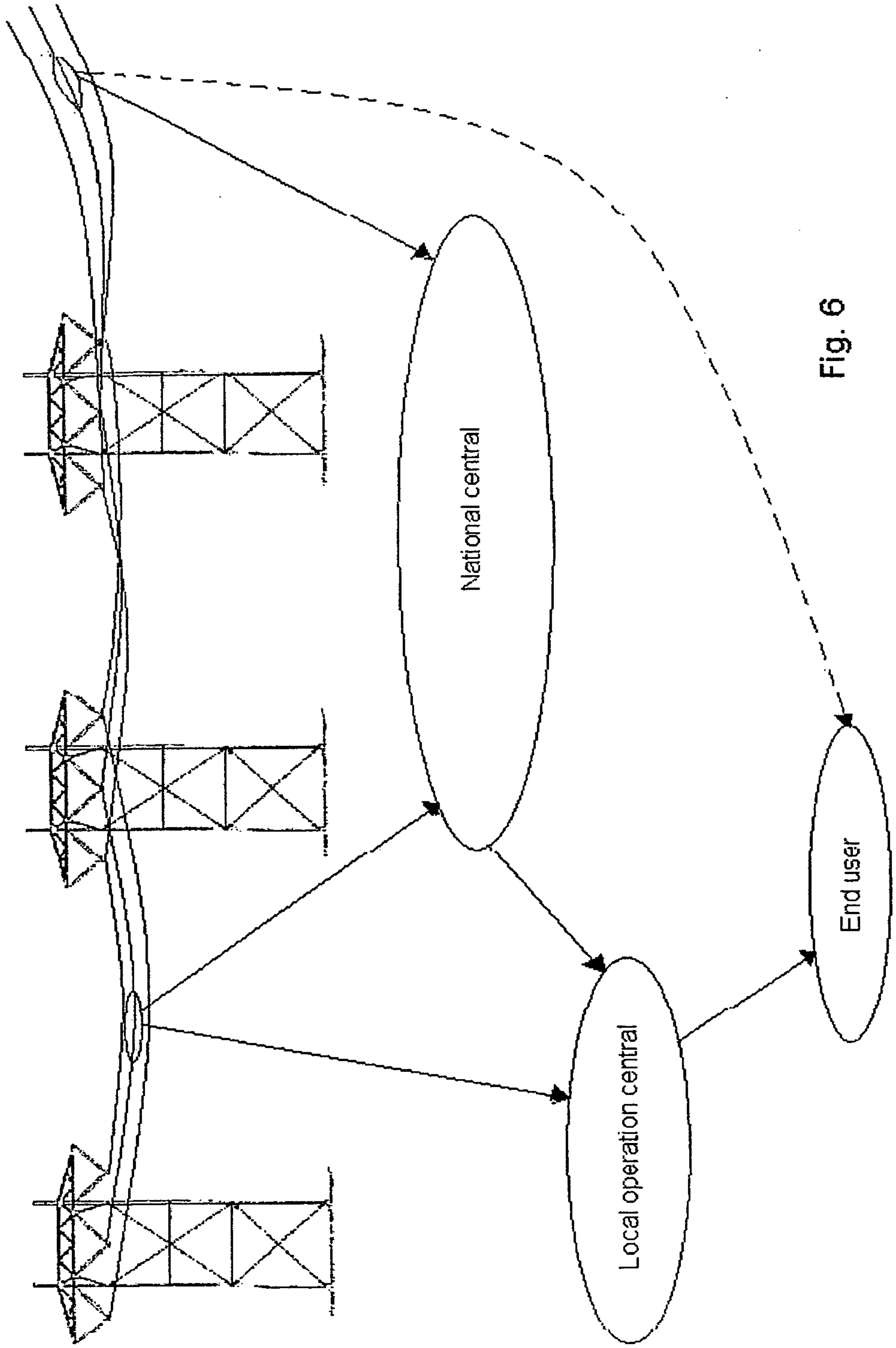
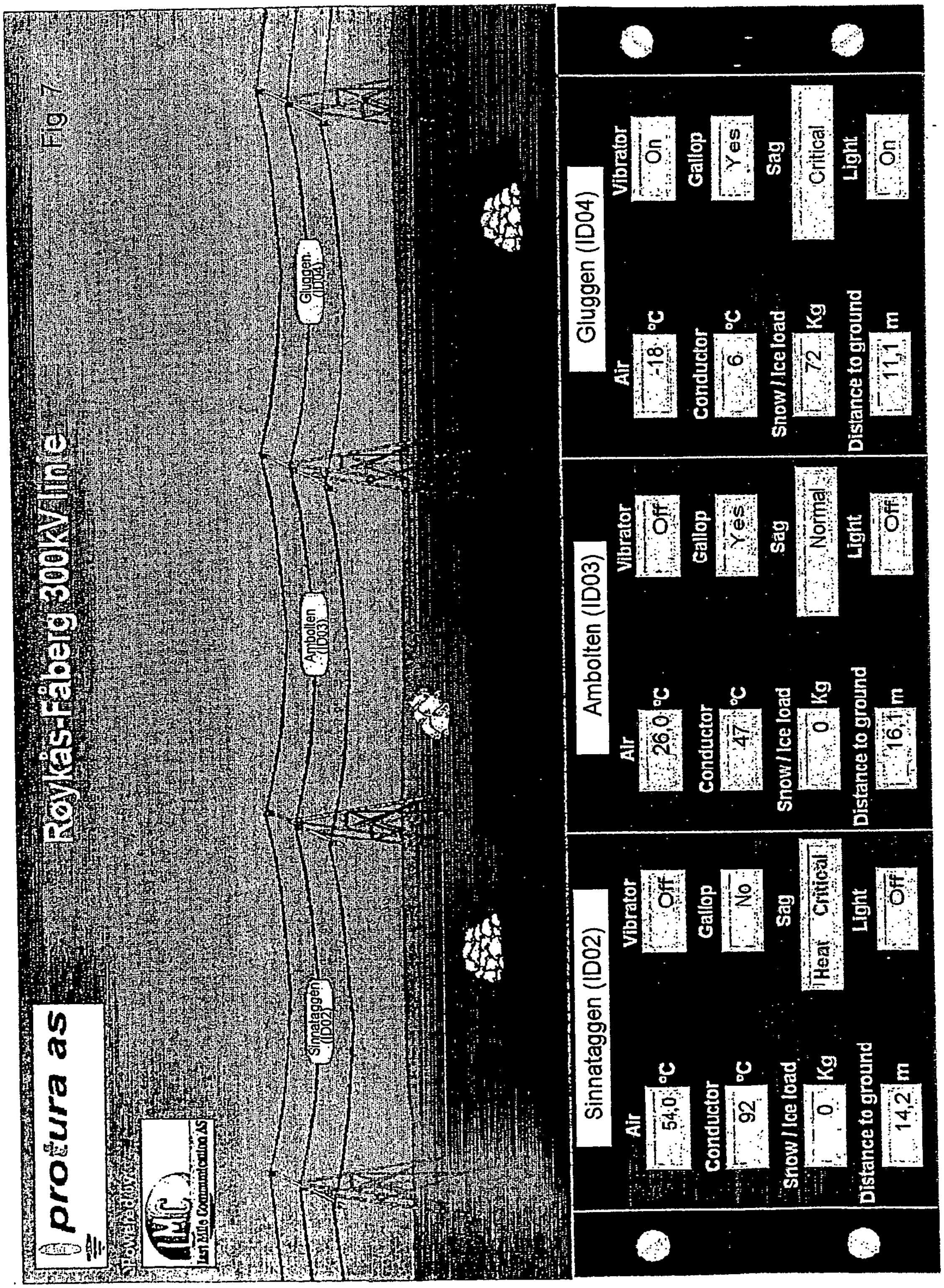


Fig. 6


Røykås-Fåberg 300kV line
Fig 7
protura as
Powered by
Last Mile Communication AS
Sinnataggen (ID02)
Ambolten (ID03)
Gluggen (ID04)
Sinnataggen (ID02)
Air 54,0 °C
Conductor 92 °C
Snow / Ice load 0 Kg
Distance to ground 14,2 m
Vibrator Off
Gallop No
Sag Heat Critical
Light Off
Ambolten (ID03)
Air 26,0 °C
Conductor 47 °C
Snow / Ice load 0 Kg
Distance to ground 16,1 m
Vibrator Off
Gallop Yes
Sag Normal
Light Off
Gluggen (ID04)
Air -18 °C
Conductor 6 °C
Snow / Ice load 72 Kg
Distance to ground 11,1 m
Vibrator On
Gallop Yes
Sag Critical
Light On

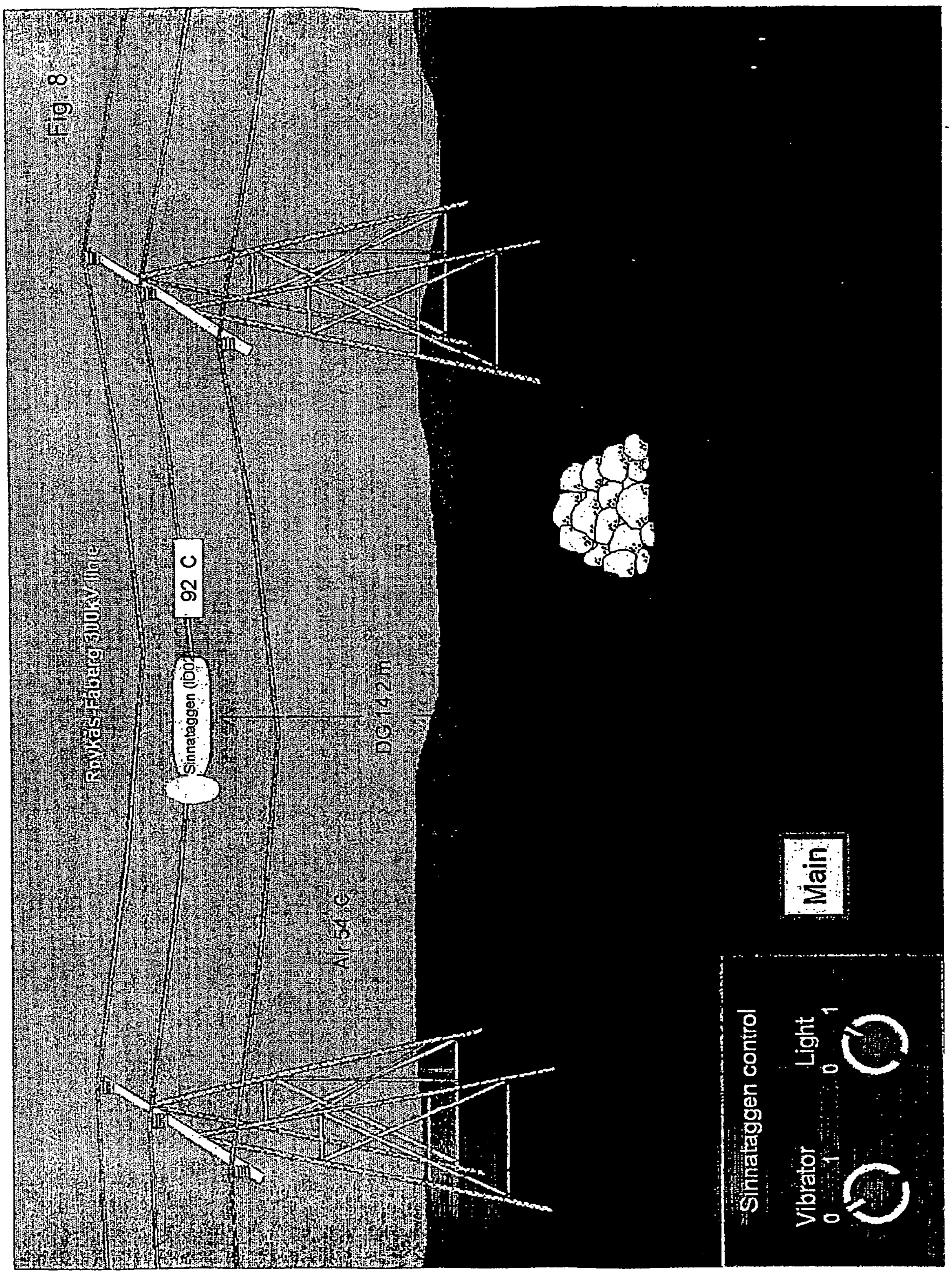


Fig. 8